THE SUCCESSIVE PRESSURE JUMP LINES OF AUGUST 16, 1954[1]

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INTRODUCTION

Two pressure jump lines moved across Washington, D. C., one after the other, within 35 minutes on August 16, 1954. The first line passed the Central Office of the Weather Bureau at 1842 EST and the second one at 1917 EST. Both pressure jump lines were traced back to western Pennsylvania where they apparently originated. Violent weather accompanied the lines from western Pennsylvania through Maryland, northern Virginia, and Delaware. Hail, strong winds, and heavy rain caused much damage in the Pittsburgh area of Pennsylvania. An unconfirmed tornado was reported near Martinsburg, W. Va., and funnels aloft were observed near Leesburg, Va. [1]. Strong winds and heavy rain were reported at several stations in the path of the two pressure jump lines which moved from Pennsylvania south-southeastward into southern Virginia and North Carolina. In this study the unusual twin system of pressure jump lines is documented and the relation of the series of severe storms to the lines is shown.

SYNOPTIC SITUATION

At 1330 EST a cold front was carried by WBAN Analysis Center extending southwestward from just north of the State of Maine to the extreme southeastern corner of Michigan. From there the front took a more west-southwestward trend, passing through extreme northern Indiana to northwestern Kansas, where it curved northwestward, becoming stationary through northeastern Wyoming and central Montana on into Canada.

The surface winds over the North Atlantic States were predominantly from the west.

A squall line, carried on the map at this time, was oriented northeast through southwest, extending from eastern Lake Erie to north-central Kentucky. The northern tip of this line was carried about 50 miles ahead of the cold front and the southern edge about 400 miles in advance of it.

Six hours later, at 1930 EST (fig. 1), the cold front had advanced southeastward about 200 miles and extended from southern Maine southwestward across New York and northwestern Pennsylvania and westward across Ohio. A squall line was carried about 40 miles southeast of Washington, D. C.

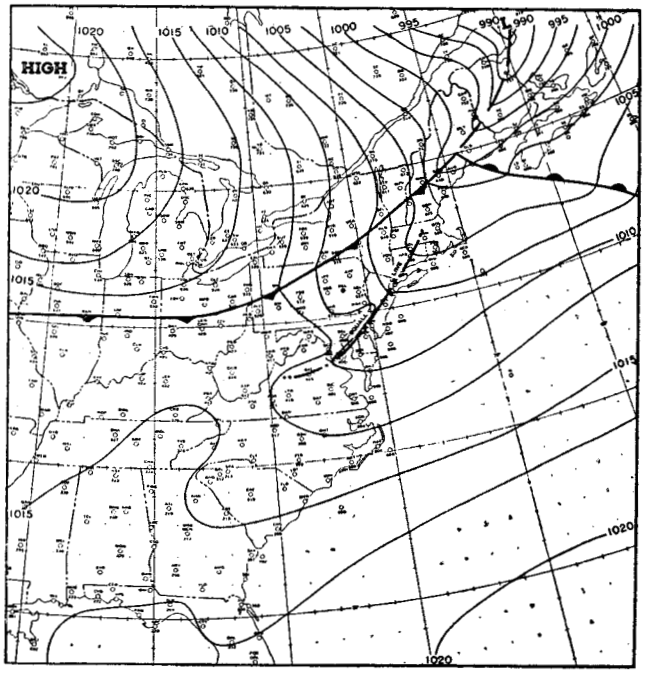

FIGURE 1.—Surface chart, 1930 EST, August 16, 1954.

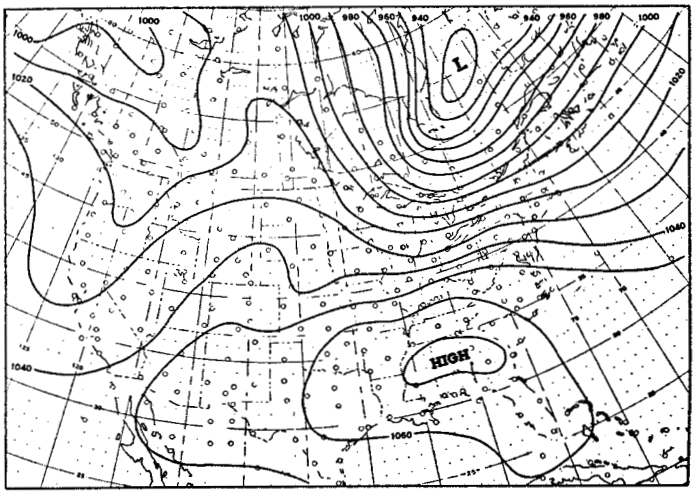

FIGURE 2.—700-mb. chart, 1000 EST, August 16, 1954.

On the 1000 EST 700-mb. analysis, a low pressure system was centered over northern Quebec Province and a high pressure system was situated over northern Alabama. (See fig. 2.) A trough line extended from the southwestern corner of Minnesota southwestward through central Nebraska into northwestern Kansas. The maximum winds were westerly between 40 and 50 knots over the

[1] The research reported on in this paper has been in part sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Center, Air Research and Development Command.

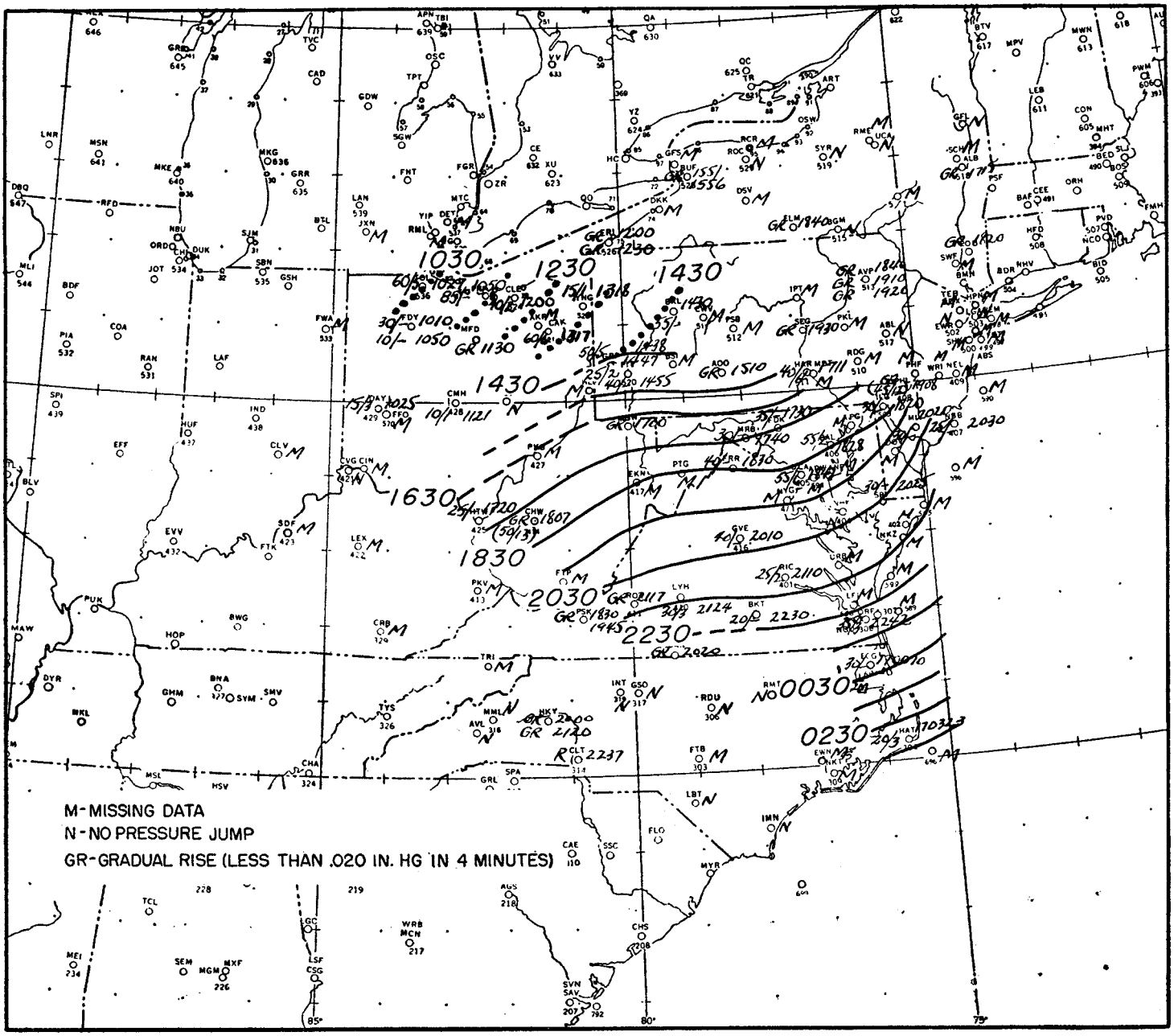

FIGURE 3.—Isochrone analysis of first pressure jump line, August 16, 1954. Basic data taken from microbarograms are indicated. To left of station circle is given the ratio of the total pressure rise (in 0.001 in. Hg) to the duration of the rise (in minutes). Dash for duration of rise means reading was from a 4-day trace. To the right of the station circle is the time of beginning of the pressure jump (EST). Dotted lines are isochrones for pressure jump line from west.

northern Great Lakes region. The winds in the vicinity of Washington, D. C., at 700 mb. were between 25 and 30 knots from the west-northwest.

On the 700-mb. chart at 2200 EST, the low center had moved to extreme northeastern Quebec and the High had moved southward into central Alabama. The main jet was through upper New York State and New England, but a secondary jet was evident over the local area with a 60-knot wind reported at Washington.

ANALYSIS OF PRESSURE JUMP LINES

Two independent areas of pressure jumps existed on August 16 and these areas seemed to join in southwestern Pennsylvania. The first series of pressure jumps was reported from Iowa eastward to Pennsylvania and began during the early morning hours. The second series of jumps began in southwestern Pennsylvania during the afternoon. An analysis of the pressure jumps from avail-

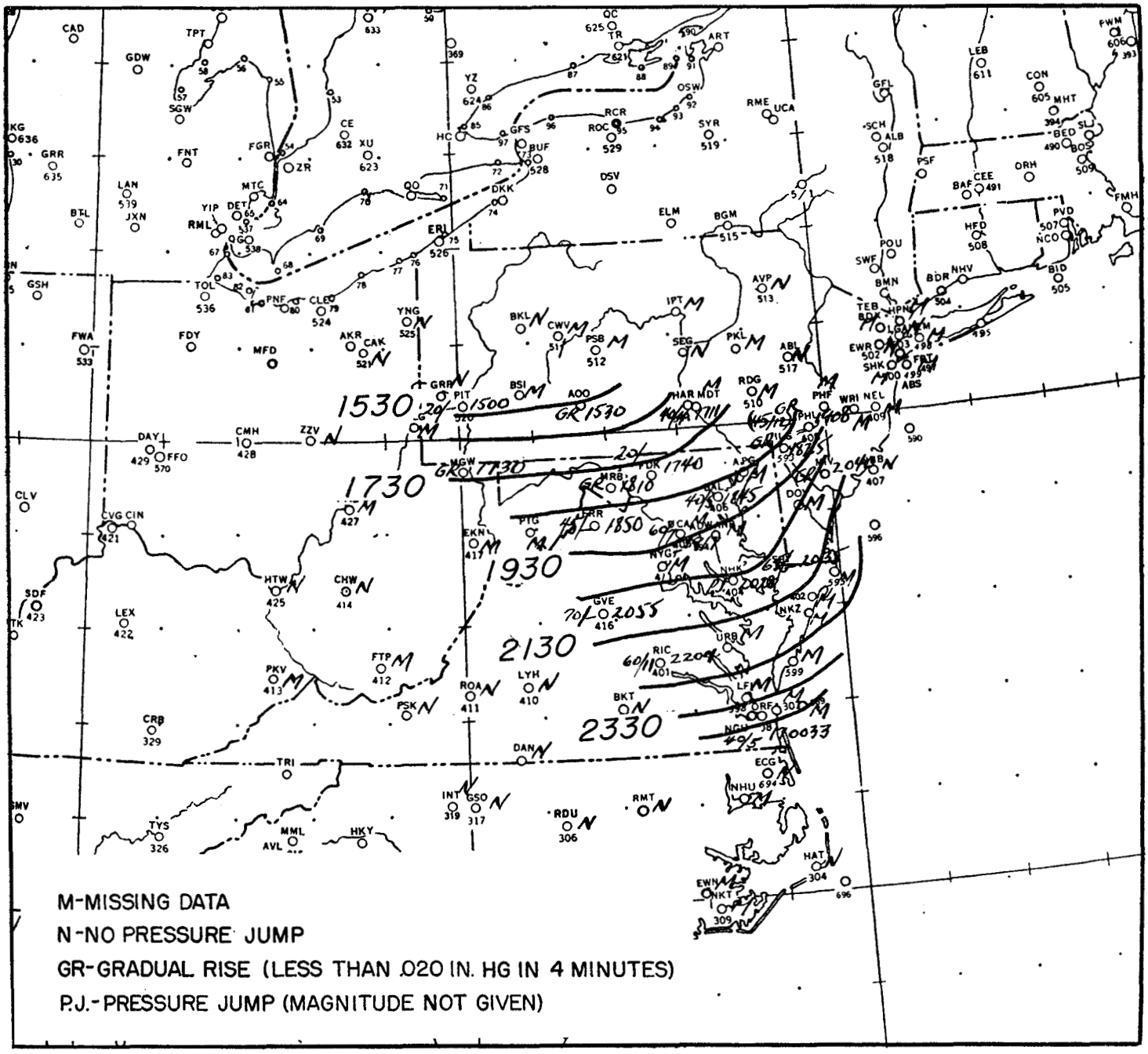

FIGURE 4.—Isochrone analysis of second pressure jump line, August 16, 1954. (See fig. 3 for description of plotting model.)

able barograms indicated a pressure jump line moving across northern Ohio into western Pennsylvania. In the latter area this line disappeared. At Pittsburgh, Pa., the existence of two pressure jumps very close to each other in time suggested that a new pressure jump line was forming in that locality at approximately 1430 EST. This new line was oriented east-northeast to west-southwest, whereas the line crossing Ohio had been oriented northeast to southwest. A careful analysis revealed no pressure jumps that would give a line oriented in the latter direction; therefore, it was concluded that the pressure jump line from Ohio dissipated in the vicinity of Pittsburgh and Brookville, Pa., at approximately 1430 EST.

Barograph traces for stations in Pennsylvania, Maryland, West Virginia, and Virginia showed two pressure jumps occurring within an hour. Analysis revealed that two pressure jump lines actually did exist, one following the other and roughly parallel to it. These two lines are the successive pressure jump lines discussed in this study, and the pressure jump line coming from the west (repre-

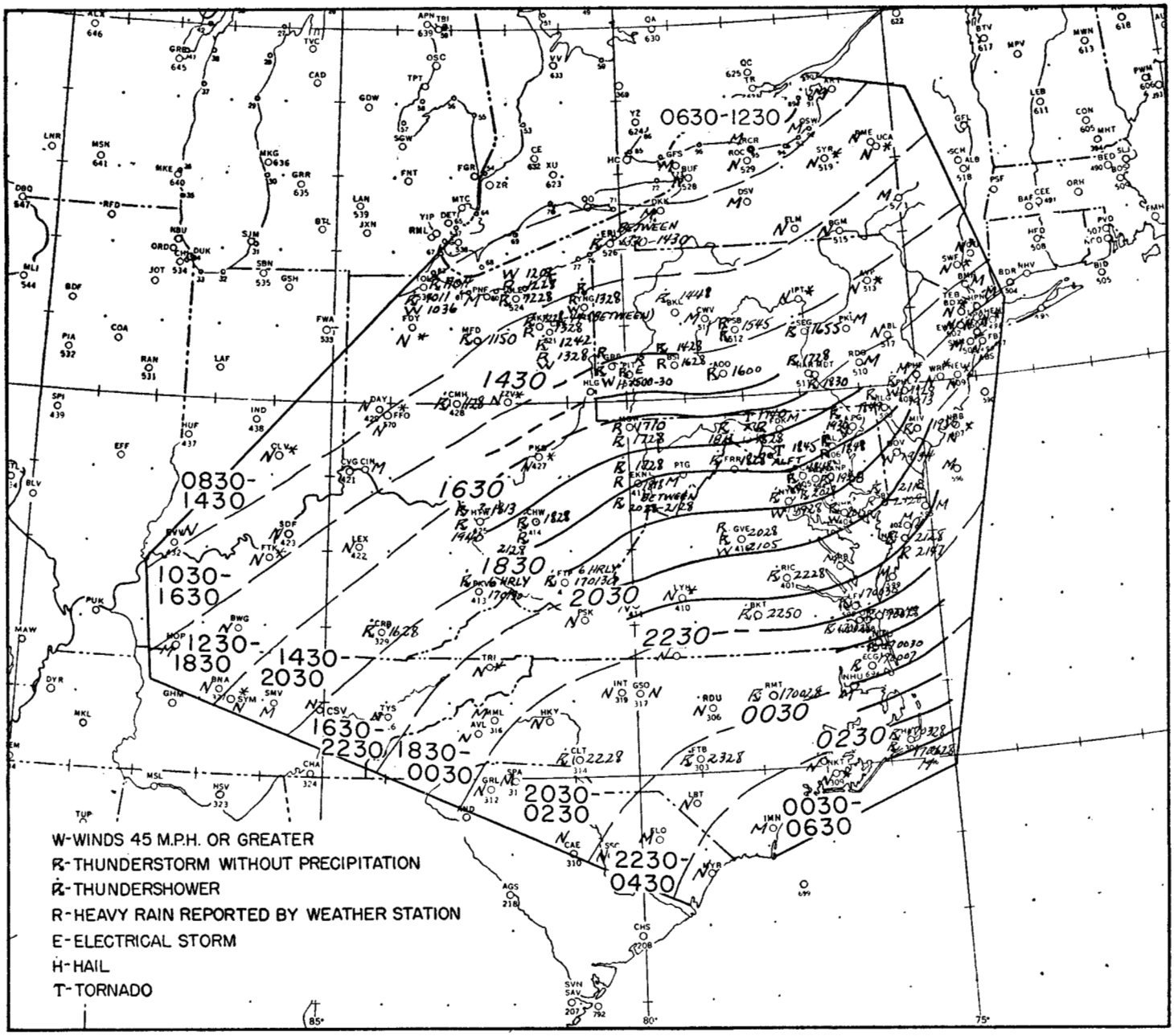

FIGURE 5.—Severe local storms along pressure jump lines. All times EST. Asterisk indicates incomplete data.

sented as a dotted line in fig. 3) is considered only in offering an explanation of the thunderstorm activity in Ohio and because of the fact that the latter line appears to have intersected the first of the two former lines in the vicinity of Pittsburgh.

Figure 3 shows the movement of the first of the pressure jump lines that originated in Pennsylvania. The first line moved from southwestern Pennsylvania to Cape Hatteras, N. C., in 13 hours (1430–0330 EST), a distance of 400 miles, giving an average speed of approximately 31 m. p. h. The width of the line (distance between ends of isochrones) was small at the beginning, approximately 120 miles. However, it grew to 340 miles at its widest point and then decreased to approximately 80 miles in width in southern Virginia and North Carolina. Some of the isochrones in figure 3 are dashed for a part of their length because of lack of data in the area. The pressure jump line is believed to have existed in such areas for reasons of continuity, nevertheless. The southwestern part of the line did not appear until jumps at Huntington and Charleston, W. Va., occurred. There is the possibility that this may have been another pressure jump line, but there are no conclusive data to substantiate this idea; therefore, all the jumps are considered to be part of the same system.

The second pressure jump line was not quite as extensive as the first. (See fig. 4.) It followed from a few minutes to a half hour behind the first line during the first half of

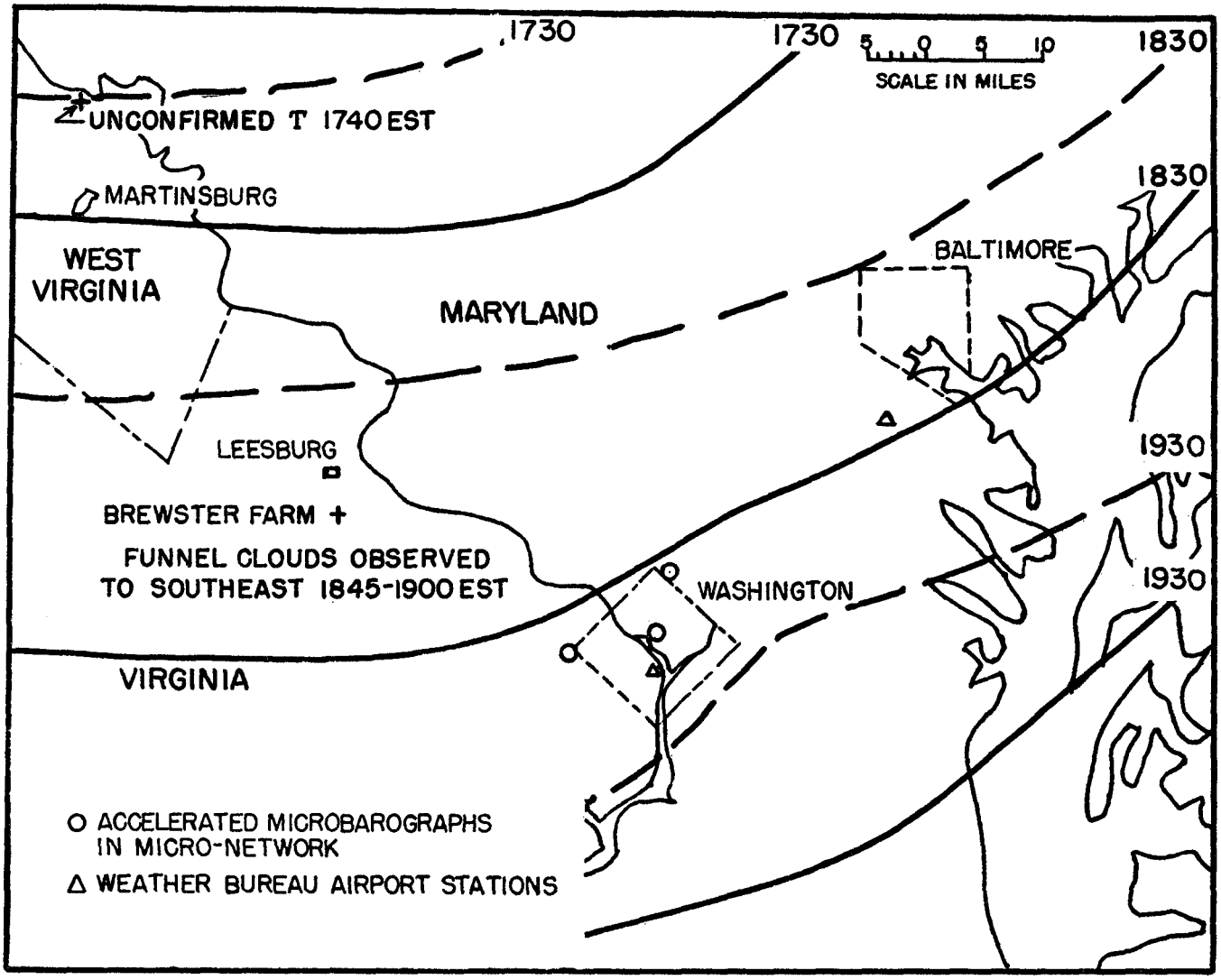

FIGURE 6.—Area surrounding Washington, D. C., showing the micro-network of accelerated microbarographs. Solid line represents isochrones of the first pressure jump line. Dashed line represents isochrones of the second pressure jump line. All times EST.

its life, but during the latter part of its existence the gap between the two lines widened and the second line was more than an hour behind the first at the end. From its place of origin in southwestern Pennsylvania, the second line, in 9 hours (1530–0030 EST), traveled to southern Virginia, a distance of 270 miles, at an approximate average speed of 30 m. p. h. At the beginning the line was 120 miles in width, but during most of its existence it was approximately 200 miles in width.

SEVERE STORMS

Figure 5 illustrates the thunderstorm activity that occurred along the pressure jump lines. Hourly weather sequences and synoptic observations were used for the most part to obtain reports of storms. Additional information was gained concerning the storm in the Pittsburgh area through a letter from the Weather Bureau City Office at Pittsburgh. The eyewitness account and sketches of the cloud formations observed near Leesburg, Va., by Brewster [1] also added to the records of storm activity. At Washington the data from the Central Office of the Weather Bureau and newspaper accounts supplemented the hourly and synoptic observations. The legend in figure 5 gives the definitions used to classify the storms.

To delineate areas of thunderstorms and areas in which there was no violent weather, zones were laid out with a 6-hour time interval for each zone centered on the middle isochrone for that particular zone. The first pressure jump line that originated in southwestern Pennsylvania was used to define the zones. It was extrapolated back to Lake Erie to cover the area to the northwest outside of the path covered by this line. The zones covered a broad area on each side of the two pressure jump lines that moved from Pennsylvania and were drawn parallel to the isochrones of the first line and what were considered to be logical extensions of the isochrones. Outside the path of the two pressure jump lines, storms within the 6-hour interval as obtained from the weather sequences were

plotted. Within the path of the pressure jump lines the time interval for each station having pressure jump data was centered on the time of occurrence of the first pressure jump and storms at these stations were selected from this time interval. Each station without pressure jump data inside the path of the pressure jump lines had a time interval centered on the isochrone nearest the station. Data for some stations were incomplete and to denote this fact an asterisk has been entered on the chart next to the station circle.

Most of the thunderstorm activity occurred along the path of the two pressure jump lines that moved across the Middle Atlantic area and coincident with their passage. Exceptions were the thunderstorms in Ohio, Kentucky, and North Carolina, which were outside the path of the two lines. Some of the most severe weather along the pressure jump lines occurred in the Pittsburgh area. The pressure jump analysis indicates the probability of an intersection of the pressure jump line from Ohio and the newly formed pressure jump line in southwestern Pennsylvania somewhere near Pittsburgh. That area had heavy rain, strong winds, hail, and severe lightning which struck several places. The following is taken from the letter written by David A. Lawson, Jr., acting meteorologist in charge at the Pittsburgh Weather Bureau City Office, dated August 17, 1954:

> Rain started to fall in downtown Pittsburgh at 1458 EST, and a few minutes before that time at the airport. Rainfall was heavy, with .73 inch falling downtown from 1500 to 1530 EST. Gusts up to 50 miles an hour were reported at the Greater Pittsburgh Airport, and hail was reported from scattered locations, particularly in the eastern sections of the Pittsburgh area. According to the Post-Gazette: "Lightning killed a 12-year-old boy, stunned a man and caused heavy property loss to buildings and utility lines."

As the new pressure jump line moved south-southeastward, another line formed and moved a short distance behind. Ten miles north of Martinsburg, W. Va., an unconfirmed tornado was reported at 1740 EST, about the time of the passage of the second pressure jump line. Several miles southeast on the Brewster farm near Leesburg, Va., protrusions were observed between 1845 and 1900 EST extending from a cloud which had passed the farm roughly 45 minutes before the observation [1]. Strong winds but no rain accompanied this cloud at the farm. From the description of the protrusions it is believed that they were funnels aloft. They were observed to the southeast of the Brewster farm, thus placing them between Leesburg and Washington, D. C., and on the first pressure jump line. Brewster related seeing a peculiar cloud to the northwest about an hour behind the cloud with the protrusions. This second cloud is believed to have been associated with the second line. Heavy rain showers and some wind accompanied it. Figure 6 shows the location of the Brewster farm on an enlarged map of the area surrounding Washington. Isochrones for the two pressure jump lines are entered to indicate the

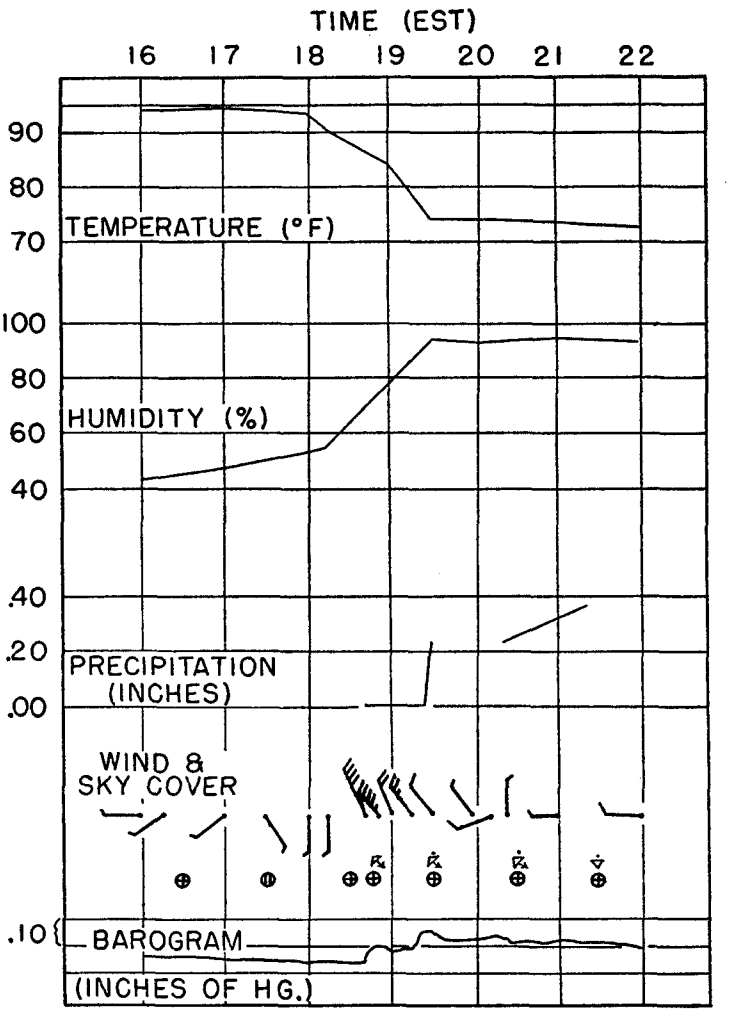

FIGURE 7.—Records from hygrothermograph, triple register, and accelerated microbarograph, Weather Bureau Central Office, Washington, D. C., August 16, 1954. Sky cover obtained from hourly sequence reports from Weather Bureau Station at National Airport.

relation of the lines to the storms which are recorded on the enlarged map. Heavy rain and strong winds were reported at many points in Maryland and northern Virginia. The weather associated with the pressure jump lines in southern Virginia and North Carolina was less violent.

When the pressure jump lines passed Washington, winds with gusts to 52 m. p. h. were observed at the Weather Bureau Station at National Airport and a thundershower occurred. The set of instruments at the Central Office (a hygrothermograph, a triple register for wind and precipitation, and a rain gage) along with the micro-network of three accelerated microbarographs, one of which is at the Central Office, gave a detailed picture of the weather associated with the pressure jump lines. Figure 6 illustrates the micro-network of accelerated microbarographs in the metropolitan area of Washington. With the occurrence of the first pressure jump at the Central Office, the wind shifted from south to northwest at 40 m. p. h. and 10 minutes later was 45 m. p. h. (See fig. 7.) During this time a trace of rain fell and the Na-

tional Airport reported thunder. The temperature dropped from 84° to 74° F. in about 30 minutes. This drop began about 20 minutes after the first pressure jump. The humidity started rising from 54 percent several minutes before the first jump until it reached a peak of 94 percent shortly after the second jump. The heaviest rain fell beginning about 8 minutes after the second pressure jump started. Within a 5-minute period, 0.23 inch of rain had fallen. The first pressure jump at the Central Office was 0.055 inch Hg (1.86 mb.) in 6 minutes at 1842 EST. The second pressure jump occurred at 1917 EST (35 minutes after the beginning of the first) and was 0.060 inch Hg (2.03 mb.) in 7 minutes.

From the description of the two clouds that passed the Brewster farm, data concerning the pressure jumps at Washington, and thunderstorm reports from the hourly sequences, it seems that the first pressure jump line was accompanied in many places by strong winds and little, if any, precipitation; whereas the second line was accompanied by thundershowers.

PRECIPITATION DISTRIBUTION

Precipitation was entered on a separate chart for the area of pressure jumps. The same zones and time intervals were used as in figure 5. Precipitation data were obtained from the hourly weather sequences and synoptic observations except at Washington, where the amount of rainfall at the Central Office was used. As can be seen from figure 8, the precipitation area, with three main exceptions, coincides closely with the two pressure jump lines being investigated. Two areas exist outside the pressure jump lines in southeastern Kentucky and southern North Carolina. The third area of precipitation in Ohio blends in with the main band of precipitation extending to the Virginia coast. The precipitation area in Ohio, excluding central Ohio, can be explained as being associated with the pressure jump line that crossed that State. The cause of precipitation in central Ohio is undetermined. The precipitation in Kentucky may have been due to convective activity. A ready explanation is not available for the precipitation in North Carolina. However, in the main area of precipitation, showers occurred close to the time of the passage of the pressure jump lines.

Figure 8 shows one area of maximum precipitation and one secondary maximum. The largest amount of rain fell in the area between Blairsville, Pa., and Akron, Ohio. The secondary maximum was in the vicinity of Salisbury and Patuxent River, Md. Both areas coincide with regions in which some of the largest pressure jumps occurred. The two areas are located on the northeast side of the path of the two pressure jump lines.

UPPER AIR DATA

Examination was made of soundings from three stations in the path of the pressure jump lines—Pittsburgh, Pa., Washington, D. C., and Norfolk, Va. The Pittsburgh

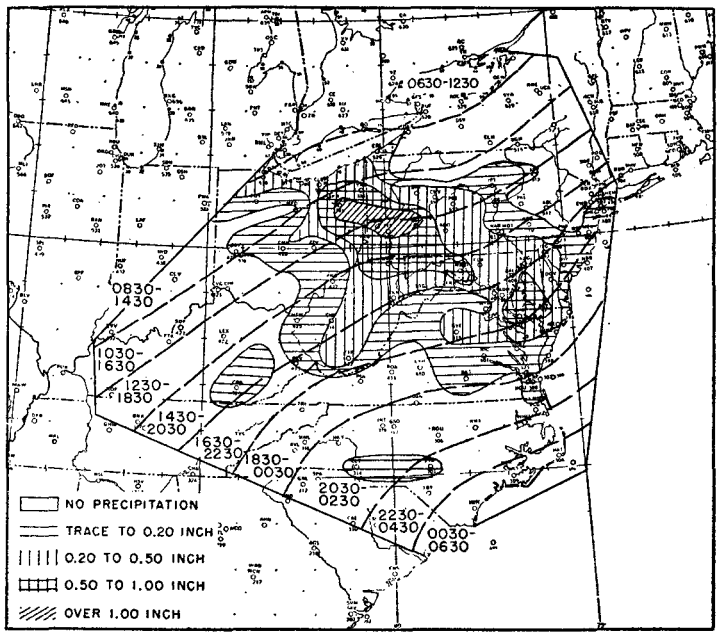

FIGURE 8.—Precipitation area along path of pressure jump lines. Precipitation in inches. Time interval in EST.

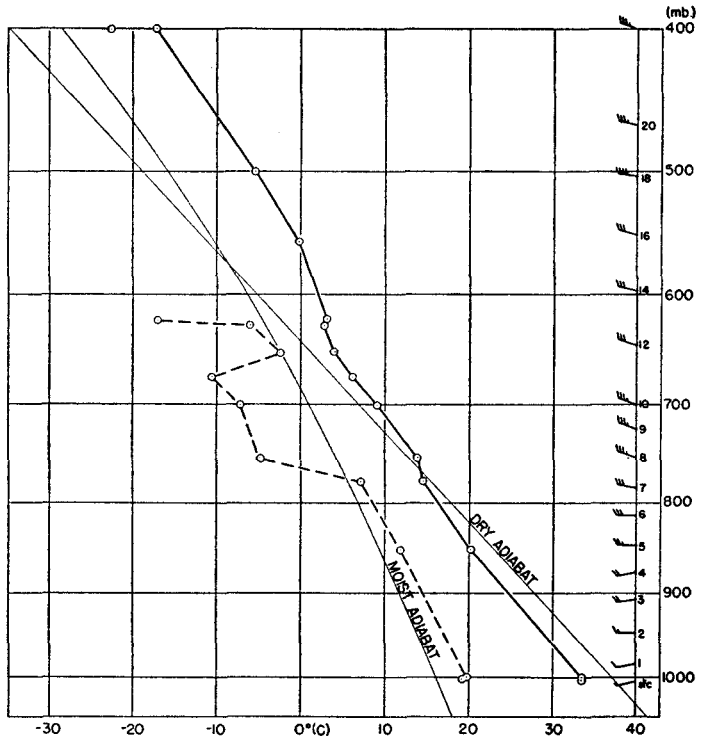

FIGURE 9.—Upper air sounding for Washington, D. C., 1600 EST, August 16, 1954. The temperature curve is represented by solid line; dew point curve by dashed line.

sounding at 1000 EST shows two inversions—one at 850 mb. and the other at 650 mb. The 1600 EST Washington sounding, figure 9, indicates an inversion at 630 mb. with a nearly isothermal layer (decrease of 0.5° C. from bottom to top of layer) between 750 mb. and 800 mb. At Norfolk the sounding at 2200 EST (less than an hour prior to the

pressure jump line passage) showed a surface inversion, a stable layer between 720 mb. and 770 mb., and isothermal layers at 600 mb. and 500 mb. The preceding sounding at 1600 EST indicated an inversion at 800 mb., with a stable layer at 600 mb. Washington and Pittsburgh were both in the warm air before the jump line passages. Norfolk was in the warm air at 1600 EST, and the surface inversion at 2200 EST was evidently due to radiational cooling. Dayton, Ohio, although outside the analyzed systems, had a marked inversion at 930 mb. and a stable layer between 650 mb. and 600 mb. at 1000 EST. Greensboro, N. C., also outside the systems, showed a stable layer at 600 mb. at 1000 EST, appearing as an isothermal layer at the 550-mb. level at 2200 EST. Of the stations checked, Washington appeared to have the strongest winds aloft. Winds of 50 knots were indicated between the 700-mb. and 550-mb. levels at 2200 EST.

Although it is difficult to determine the exact origin of the pressure jump lines, it is possible that they were initiated at the front and moved rapidly ahead of it. It is believed, from the examination of the soundings, that the gravity waves producing the pressure jumps traveled between the 850-mb. and 750-mb. levels [2], since there was an inversion surface or isothermal layer between those levels at the time the pressure jump lines moved through the area. However, propagation of both the gravity waves, or at least one of them, near the 600-mb. level should not be ruled out since an isothermal layer or inversion existed near that level during the time interval of the two pressure jump lines that originated in southwestern Pennsylvania.

SUMMARY

Two pressure jump lines formed in southwestern Pennsylvania during the middle of the afternoon on August 16, 1954 and moved south-southeastward to North Carolina and southern Virginia during the early morning hours of August 17. The first line was followed by the second line with an average time interval of about 30 minutes. Considerable thunderstorm activity, some severe, occurred along the two lines. From available data it seems that most of the strong winds occurred with the first pressure jump line and the rain with the second pressure jump line. A pressure jump line moving across Ohio from the west is believed to have intersected the first pressure jump line near Pittsburgh, Pa. It is believed that the former pressure jump line ended in western Pennsylvania.

Two pressure jump lines that originated in Pennsylvania are believed to have been propagated at a level between 850 and 750 mb.

ACKNOWLEDGMENTS

Helpful suggestions and assistance were given the authors by Dr. Morris Tepper and the other members of the Severe Local Storms Research Unit.

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2. Morris Tepper, "The Application of the Hydraulic Analogy to Certain Atmospheric Flow Problems," *Research Paper* No. 35, U. S. Weather Bureau, Washington, D. C., October 1952, pp. 20–23.